REMARKS

Objections to the Drawings

The Examiner stated that the sheets of drawings filed on April 8, 2002 have been received but not approved because the Applicants have not submitted a proposed drawing correction in the form of a pen-and-ink sketch showing the changes in red.

The Applicants respectfully submit herewith pen-and-ink changes to the drawings in red as required under MPEP §608.2(v).

The Applicants respectfully submit that flow arrows for the injected fluid have been added to Figures 2B, 3B, 3C, 3D, and 3E. The Applicants respectfully submit that the pitch vector has been modified in Figure 5B to more clearly show that this vector has a vertical component directing the vector into the page.

The Applicants respectfully submit that the angle for 286 of 15° is relative to the longitudinal axis of the engine.

The Applicants respectfully submit that these changes to the drawings address the Examiner's objections and request that these objections be withdrawn and the drawings entered.

Claim Rejections Under 35 USC § 112

The Applicants respectfully submit that independent Claims 31, 44, 51, and 63 have been amended to overcome the Examiner's rejections for the use of negative limitations.

Therefore, the Applicants request that the Examiner withdraw the objections to amended claims under 35 USC § 112.

Rejections Under 35 USC § 103

Claims 51-54, 56, 57, 66-69, 63-69, stand rejected under 35 USC 103(a) as being unpatentable over McCullough (3,698,642) in view of either Ernst (3,294,323) or the AIAA paper of Miller et al. (AIAA 95-2603) of the IDS.

The Examiner states that "McCullough teaches a nozzle having a primary flow, a primary injector 16, and a secondary injector 18, and valve controllers 22 to direct a flow to vary the effective throat area of the nozzle and perform thrust vectoring (top of col. 2). McCullough further teaches the use of fuel (col. 2, lines 26-28). Alternately, for the controllers, it is clear that the valves require a controller to actuate them. It would have been obvious to one of ordinary skill in the art to employ a software based controller in addition to the valves, in order to provide the necessary control over the thrust vectoring and/or throat control. McCullough do not teach the primary and secondary injectors are inclined to oppose the flow."

The Examiner further states "Ernst teaches that it is old and well known in the thrust vectoring art to employ primary and secondary injectors 1, 3 that are either angled perpendicular to the primary flow (Fig. 1) or included to oppose the flow (Fig. 3) and shows that the effective vector O can be increased by using opposed flow (compared Fig. 3 to Fig. 1)."

With respect to Miller et al., the Examiner states "Miller et al. teach a fixed geometry exhaust nozzle used for gas turbine/turbofan engines (which inherently employ compressors) where the nozzle area is varied by a cross flow injected in the upstream direction (Figs. 2-5) in order to achieve a variable throat area. At the throat, the primary flow reaches the sonic condition. Miller shows on the cover

sheet of the paper that the flows from the primary and secondary injectors can be angled to oppose the flow. Miller et al. further teach very low injection angles are possible (see top left of fig. 9) and hence, as the angles are very low, the angles will also be approximately parallel the vector angle, which would also be low."

The Examiner concludes: "It would have been obvious to one of ordinary skill in the art to incline the injectors of McCullough to oppose the flow, as taught by either Ernst or Miller et al., in order to enhance the effectiveness of the thrust vectoring and/or to employ an alternative means of vectoring well established in the art. As for using the nozzle with a jet engine aboard an aircraft, this is taught by the Miller paper. It would have been obvious to one of ordinary skill in the art to employ the nozzle with a jet aircraft, as a well known application of such a nozzle."

Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims in Claims 31, 44, 51, and 63 that the injected flow skews the sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

The Applicants respectfully teach that Ernest teaches away from the subject matter of the present invention in that Ernest teaches thrust vectoring through the use of liquid vaporizations (Ernest; col. 2, lines 35-40). The present invention does not inject a liquid which then undergoes a phase change (vaporization) into the primary fluid flow. Additionally, the Applicants respectfully submit that Ernest vectors the primary flow through the Coanda effect. Ernest can be distinguished from the present invention as Ernest teaches that the primary flow may be vectored by a wall attachment effect. Ernest describes that a single liquid injection will cause the primary flow to lock on and remain locked on to the nozzle wall in the absence of another liquid injection (Ernest; col. 2, lines 5-13). Additionally, Ernest does not teach that the effective sonic plane and throat of the nozzle are skewed by the injection of liquid into the primary flow.

The Applicants submit that the present invention as recited in the claims does not use the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, effective location, and effective orientation of the nozzle throat or sonic plane, no matter the physical configuration of the nozzle or duct containing the primary flow.

Therefore, the Applicants respectfully submit that one would not apply the teachings of McCullough, Ernst, or Miller to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector

control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

Claims 51-69 stand rejected under 35 USC 103(a) as being unpatentable over McCullough (3,698,642) in view of either Ernst (3,294,323) or the AIAA paper of Miller et al. (AIAA 95-2603) of the IDS, as applied above, and further in view of either Kranz et al. (4,351,479) or Warren (3,204,405).

The Examiner states: "McCullough teaches various aspects of Applicant's claimed invention but does not teach the flow is pulsed. Kranz et al. teach a jet engine nozzle 7 having a plurality of injectors (a-f) spaced about the housing, and valve controllers 36 associated with the injectors, the controller directing the injectors to provide an unsteady, i.e., pulsed, fluidic cross flow. The pulsed cross flow is injected to control the effective flow area, throttle and also vector the primary fluidic flow (see especially col. 5, lines 9 and following). The pulsed cross flow partially blocks the opening of the nozzle and can be either symmetric (area control) or asymmetric (thrust vectoring) as desired. Please note that as the effective flow area for the primary fluid flow is controlled, the temperature and pressure of the primary gas is inherently controlled by variation of the primary fluid flow velocity. The pulsed cross flow controller inherently controls the frequency, amplitude and wave form of the pulses. Kranz et al. teach that by employ pulsed flow, more effective deflection of the incoming flow is achieved (col. 1, lines 7 and following). Warren et al. teach a thrust vectoring system for a reaction engine where pulsed flow (col. 9, lines 2 and following, especially circa line 63) is injected at the throat (e.g. Fig. 6a, 11, 121) to provide vectoring of the primary fluid. Warrant also teach that the pulsed fluid can be fuel. It would have been obvious to one of ordinary skill in the art to employ pulsed flow of the

cross flow injected by McCullough, as taught by either Kranz et al. or Warren et al., to more effective control the cross flow penetration of McCullough, and to enhance the thrust vectoring ability."

Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims in Claim 75 that the asymmetric cross flow from the injectors skews sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

The Applicants respectfully teach that Ernest teaches away from the subject matter of the present invention in that Ernest teaches thrust vectoring through the use of liquid vaporizations (Ernest; col. 2, lines 35-40). The present invention does not inject a liquid which then undergoes a phase change (vaporization) into the primary fluid flow. Additionally, the Applicants respectfully submit that Ernest vectors the primary flow through the Coanda effect. Ernest can be distinguished from the present invention as Ernest teaches that the primary flow may be vectored by a wall attachment effect. Ernest describes that a single liquid

injection will cause the primary flow to lock on and remain locked on to the nozzle wall in the absence of another liquid injection (Ernest; col. 2, lines 5-13). Additionally, Ernest does not teach that the effective sonic plane and throat of the nozzle are skewed by the injection of liquid into the primary flow.

The Applicants submit that the present invention as recited in the claims does not use the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, effective location, and effective orientation of the nozzle throat or sonic plane, no matter the physical configuration of the nozzle or duct containing the primary flow.

The Examiner states that Kranz teaches a nozzle having a plurality of injectors based about a nozzle to provide an unsteady fluidic flow. The pulsed cross flow is injected to control the effective flow area, throttle and vector the primary fluidic flow (Kranz: column 5, lines 9 and following). The Applicants respectfully submit that Kranz et al. also teaches the use of the Coanda effect with fluidic jet deflection by control pulses which shift the primary flow from one wall of the nozzle to another wall of the nozzle (Kranz: column 1, lines 24-30). Furthermore, Kranz et al. states that a control pulse is only necessary for the duration of the switching process. As soon as the thrust jet (primary flow) is deflected into one of the pockets shown in 16-20 (shown in Kranz Figure 1), the primary flow remains automatically and without any further control pulse under the action of the Coanda effect (Kranz: column 1, lines 9-28).

One skilled in the art would not apply the teachings of Kranz et al. to the present invention in that Kranz teaches

according to the historical approach of shock vector control. This is applicable where a nozzle has an expansion area ratio typically between 3 to 10. Such a nozzle is widened beyond the expansion ratio corresponding to the ambient pressure (Kranz: column 1, lines 17-19). Throat skewing as claimed by the present invention cannot be applied to an over-expanded nozzle. Furthermore, the Applicants respectfully submit that shock vector control also cannot be applied to the small area expansion ratio nozzle as taught and claimed by the present invention. The present invention injects the secondary flow into the subsonic portion of the flow field preventing the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-17). The Applicants respectfully submit that the prior art does not teach the skewing of the throat or sonic plane of a nozzle as taught and claimed by the present invention. Additionally, the nozzle's thrust efficiency is greatly increased in the present invention. One might encounter an efficiency of 0.9 when using shock vector control, while one would encounter 0.95 with the small area expansion ratio nozzle claimed by the present invention.

The Applicants respectfully submit that Warren teaches away from the subject matter of the present invention in that Warren teaches a thrust-vectoring system for a reaction jet nozzle wherein a pulse flow is injected at the throat in order to vector the primary fluid. The pulsed fluid is of short duration and thus continuous control fluid streams are not required to maintain a proper deflection of the propelling jet. (Warren: column 9, lines 63-67). Additionally, the Applicants respectfully submit that Warren vectors the primary flow through the Coanda effect. Warren can be distinguished from the present invention as Warren teaches that the primary

flow may be vectored by the Coanda effect (a wall attachment effect). Warren describes that a single fluid pulse or jet issuing from one of the control nozzles will cause the propelling jet (primary flow) to lock on and remain locked on to the nozzle wall in the absence of another fluid pulse from another control nozzle. (Warren: column 9, lines 59-63.) Coanda observed that a stream of fluid exiting a nozzle tends to follow a nearby curved or flat surface as long as the curvature of the surface with respect to the fluid flow is not too sharp.

The Applicants submit that the present invention as recited in independent Claims 31, 44, 51, and 63 do not utilize the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, location, and orientation of the nozzle throat (see Claims 31, 44, 51, and 63). This allows a user to not merely manipulate the direction of the primary flow through in a discrete fashion as taught in the prior art with the use of the Coanda effect. Rather, one can continuously vector the primary flow and area, location, and orientation of the nozzle throat.

The Applicants respectfully submit that the Coanda effect merely allows the creation of a binary device where the thrust may be vectored either in a first or second direction. The present invention in comparison claims a smooth and continuous control system for vectoring the exhaust thrust by manipulating the size, location, and orientation of the sonic plane within the nozzle throat.

Applicants respectfully submit that in an alternate embodiment, Warren still only teaches the Coanda effect to provide a tri-stable flow patter. Warren states that in this

embodiment, that control fluid, supplied through one wall to the separated boundary layer, causes deflection of the propelling jet away from the control fluid input. The propelling jet thereupon clings to the opposite wall until the control signal is discontinued, at which time it returns to a center flow position (Warren: column 9, line 72; column 10, line 4).

The Applicants respectfully submit that the present invention does not provide a pulsed control signal to serve as a binary switch for vectoring the primary flow of a nozzle, rather the present invention claims a pulsed cross flow that provides a smooth, continuous control signal with which to vector the primary flow of the nozzle by controlling the size, location, and orientation of the sonic plane (or throat) of the nozzle in the present invention. This is taught in the present invention as the pulsed fluidic cross flow that has a predetermined frequency, amplitude or wave injector that is controlled by a controller associated with the injector (U.S. patent Application 09/621,795; page 20, lines 1-25).

The present invention is distinguishable from the prior art of Warren, which utilizes the Coanda effect. A fluidic amplifier device such as those taught in Warren is not robust against errors in the control function as the Coanda effect is unstable as downstream disturbances may propagate upstream in the exhaust flow to redirect the primary flow from one wall of the divergent portion of the nozzle to another. This type of thrust vector control is inadequate for uses such as aircraft control, as claimed by the present invention in Claims 31, 44, 51, and 63.

Therefore, the Applicants respectfully submit that one would not apply the teachings of McCullough, Ernst, Miller et al., Kranz et al., or Warren to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

Claims 51-54, 56, 57, 69-65, and 63-39, stand rejected under 35 USC 103(a) as being unpatentable over the AIAA paper of Miller et al. (AIAA 95-2603) of the IDS in view of McCullough (3,698,642). The Examiner states: "Miller et al. teach a fixed geometry exhaust nozzle used for gas turbine/turbofan engines (which inherently employ compressors) where the nozzle area is varied by a cross flow injected in the upstream direction (Figs. 2-5) in order to achieve a variable throat area. At the throat, the primary flow reaches the sonic condition. Miller et al. show on the cover sheet of the paper that the flows from the primary and secondary injectors can be angled to oppose the flow. Miller et al. do not teach thrust vectoring. However, it is clear that in a fixed nozzle, thrust vectoring capacities are generally required in order to steer the nozzle, especially in a military aircraft. Miller et al. further teach very low injection angles are possible (see top left of Fig. 9) and hence, as the angles are very low, the angles will also be approximately parallel the vector angle, which would also be low. McCullough teaches a nozzle having a primary flow, a primary injector 16, and a secondary injector 18, and valve controllers 22 to direct a flow to vary the effective throat area of the nozzle and perform thrust vectoring (top of col. 2). McCullough further teaches the use of fuel (col. 2, lines

26-28). Alternately, for the controllers, it is clear that the valves require a controller to actuate them. It would have been obvious to one of ordinary skill in the art to employ a software based controller in addition to the valves, in order to provide the necessary control over the thrust vectoring and/or throat control. It would have been obvious to one of ordinary skill in the art to both control the throat area and thrust vector the nozzle of Miller et al., as taught by McCullough, in order to add vectoring capabilities to the nozzle of Miller et al."

Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims in Claim 75 that the asymmetric cross flow from the injectors skews sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

Therefore, the Applicants respectfully submit that one would not apply the teachings of McCullough and Miller to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary

flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

Claims 51-69 stand rejected under 35 USC 103(a) as being unpatentable over the AIAA paper of Miller et al. (IAA 95-2603) of the IDS in view of McCullough (3,698,642), as applied above and further in view of either Kranz et al. (4,351,479) or Warrant (3,204,405).

The Examiner states: "Miller et al. teach various aspects of Applicant's claimed invention but does not teach pulsing the flows nor the flows being fuel. Kranz et al. teach a jet engine nozzle 7 having a plurality of injectors (a-f) spaced about the housing, and valve controllers 36 associated with the injectors, the controller directing the injectors to provide an unsteady, i.e. pulsed, fluidic cross flow. The pulsed cross flow is injected to control the effective flow area, throttle and also vector the primary fluidic flow (see especially col. 5, lines 9 and following). The pulsed cross flow partially blocks the opening of the nozzle and can be either symmetric (area control) or asymmetric (thrust vectoring) as desired. Please note that as the effective flow area for the primary fluid flow is controlled, the temperature and pressure of the primary gas is inherently controlled by variation of the primary fluid flow velocity. The pulsed cross flow controller inherently controls the frequency, amplitude and wave form of the pulses. Kranz et al. teach that by employ pulsed flow, more effective deflection of the incoming flow is achieved (col. 1, lines 7 and following). Warren et al. teach a thrust vectoring system for a reaction engine where pulsed flow (col. 9, lines 2 and following, especially circa line 63) is injected at the throat (e.g. Fig. 6a, 11, 121) to provide vectoring of the primary fluid. Warrant also teach that the pulsed fluid can be fuel. It

would have been obvious to one of ordinary skill in the art to employ pulsed flow of the cross flow injected by Miller et al., as taught by either Kranz et al. or Warren et al., to more effective control the cross flow penetration, and to enhance the thrust vectoring ability.

Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims in Claim 75 that the asymmetric cross flow from the injectors skews sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

The Examiner states that Kranz teaches a nozzle having a plurality of injectors based about a nozzle to provide an unsteady fluidic flow. The pulsed cross flow is injected to control the effective flow area, throttle and vector the primary fluidic flow (Kranz: column 5, lines 9 and following). The Applicants respectfully submit that Kranz et al. also teaches the use of the Coanda effect with fluidic jet deflection by control pulses which shift the primary flow from one wall of the nozzle to another wall of the nozzle (Kranz: column 1, lines 24-30). Furthermore, Kranz et al. states that

a control pulse is only necessary for the duration of the switching process. As soon as the thrust jet (primary flow) is deflected into one of the pockets shown in 16-20 (shown in Kranz Figure 1), the primary flow remains automatically and without any further control pulse under the action of the Coanda effect (Kranz: column 1, lines 9-28).

One skilled in the art would not apply the teachings of Kranz et al. to the present invention in that Kranz teaches according to the historical approach of shock vector control. This is applicable where a nozzle has an expansion area ratio typically between 3 to 10. Such a nozzle is widened beyond the expansion ratio corresponding to the ambient pressure (Kranz: column 1, lines 17-19). Throat skewing as claimed by the present invention cannot be applied to an over-expanded nozzle. Furthermore, the Applicants respectfully submit that shock vector control also cannot be applied to the small area expansion ratio nozzle as taught and claimed by the present invention. The present invention injects the secondary flow into the subsonic portion of the flow field preventing the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-17). The Applicants respectfully submit that the prior art does not teach the skewing of the throat or sonic plane of a nozzle as taught and claimed by the present invention. Additionally, the nozzle's thrust efficiency is greatly increased in the present invention. One might encounter an efficiency of 0.9 when using shock vector control, while one would encounter 0.95 with the small area expansion ratio nozzle claimed by the present invention.

The Applicants respectfully submit that Warren teaches away from the subject matter of the present invention in that Warren teaches a thrust-vectoring system for a reaction jet

nozzle wherein a pulse flow is injected at the throat in order to vector the primary fluid. The pulsed fluid is of short duration and thus continuous control fluid streams are not required to maintain a proper deflection of the propelling jet. (Warren: column 9, lines 63-67). Additionally, the Applicants respectfully submit that Warren vectors the primary flow through the Coanda effect. Warren can be distinguished from the present invention as Warren teaches that the primary flow may be vectored by the Coanda effect (a wall attachment effect). Warren describes that a single fluid pulse or jet issuing from one of the control nozzles will cause the propelling jet (primary flow) to lock on and remain locked on to the nozzle wall in the absence of another fluid pulse from another control nozzle. (Warren: column 9, lines 59-63.) Coanda observed that a stream of fluid exiting a nozzle tends to follow a nearby curved or flat surface as long as the curvature of the surface with respect to the fluid flow is not too sharp.

The Applicants submit that the present invention as recited in independent Claims 31, 44, 51, and 63 do not utilize the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, location, and orientation of the nozzle throat. This allows a user to not merely manipulate the direction of the primary flow through in a discrete fashion as taught in the prior art with the use of the Coanda effect. Rather, one can continuously vector the primary flow and area, location, and orientation of the nozzle throat.

The Applicants respectfully submit that the Coanda effect merely allows the creation of a binary device where the

thrust may be vectored either in a first or second direction. The present invention in comparison claims a smooth and continuous control system for vectoring the exhaust thrust by manipulating the size, location, and orientation of the sonic plane within the nozzle throat.

Applicants respectfully submit that in an alternate embodiment, Warren still only teaches the Coanda effect to provide a tri-stable flow patter. Warren states that in this embodiment, that control fluid, supplied through one wall to the separated boundary layer, causes deflection of the propelling jet away from the control fluid input. The propelling jet thereupon clings to the opposite wall until the control signal is discontinued, at which time it returns to a center flow position (Warren: column 9, line 72; column 10, line 4).

The Applicants respectfully submit that the present invention does not provide a pulsed control signal to serve as a binary switch for vectoring the primary flow of a nozzle, rather the present invention claims a pulsed cross flow that provides a smooth, continuous control signal with which to vector the primary flow of the nozzle by controlling the size, location, and orientation of the sonic plane (or throat) of the nozzle in the present invention. This is taught in the present invention as the pulsed fluidic cross flow that has a predetermined frequency, amplitude or wave injector that is controlled by a controller associated with the injector (U.S. patent Application 08/906,731; page 16, lines 1-25).

The present invention is distinguishable from the prior art of Warren, which utilizes the Coanda effect. A fluidic amplifier device such as those taught in Warren is not robust against errors in the control function as the Coanda effect is unstable as downstream disturbances may propagate upstream in the exhaust flow to redirect the primary flow from one wall of

the divergent portion of the nozzle to another. This type of thrust vector control is inadequate for uses such as aircraft control, as claimed by the present invention.

Therefore, the Applicants respectfully submit that one would not combine the teachings of Miller, McCullough, Kranz et al., or Warren to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

Claims 31-35, 37-39, 40-42, 44-46, and 48 stand rejected under 35 USC 103(a) as being unpatentable over Miller et al. and McCullough, and further in view of either Ernst (3,294,323) or the AIAA paper of Miller et al. (AIAA 95-2603) or AIAA paper of Miller et al. (AIAA 95-2603) of the IDS in view of McCullough (3,698,642), as applied above, and further in view of either Terrier (5,665,415) or Justice (6,000,635).

The Examiner states: "The above prior art teach various aspects of applicant's claimed invention but do not specifically teach a 3-D fixed nozzle. Terrier teaches (fig. 8) that ultra high aspect ratio biconvex aperture nozzles are old and well known in the fixed nozzle art. Justice teaches that it is old and well known in the fixed nozzle art employ an ultra high aspect ratio trapezoid aperture nozzle 33B (col. 2, circa line 63). It would have been obvious to one of ordinary skill in the art employ a 3-D nozzle, including either an ultra high aspect ratio biconvex or trapezoid aperture nozzle, as well known types of fixed nozzles utilized in the art.

Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims in Claim 75 that the asymmetric cross flow from the injectors skews sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

The Examiner states that Kranz teaches a nozzle having a plurality of injectors based about a nozzle to provide an unsteady fluidic flow. The pulsed cross flow is injected to control the effective flow area, throttle and vector the primary fluidic flow (Kranz: column 5, lines 9 and following). The Applicants respectfully submit that Kranz et al. also teaches the use of the Coanda effect with fluidic jet deflection by control pulses which shift the primary flow from one wall of the nozzle to another wall of the nozzle (Kranz: column 1, lines 24-30). Furthermore, Kranz et al. states that a control pulse is only necessary for the duration of the switching process. As soon as the thrust jet (primary flow) is deflected into one of the pockets shown in 16-20 (shown in Kranz Figure 1), the primary flow remains automatically and

without any further control pulse under the action of the Coanda effect (Kranz: column 1, lines 9-28).

One skilled in the art would not apply the teachings of Kranz et al. to the present invention in that Kranz teaches according to the historical approach of shock vector control. This is applicable where a nozzle has an expansion area ratio typically between 3 to 10. Such a nozzle is widened beyond the expansion ratio corresponding to the ambient pressure (Kranz: column 1, lines 17-19). Throat skewing as claimed by the present invention cannot be applied to an over-expanded nozzle. Furthermore, the Applicants respectfully submit that shock vector control also cannot be applied to the small area expansion ratio nozzle as taught and claimed by the present invention. The present invention injects the secondary flow into the subsonic portion of the flow field preventing the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-17). The Applicants respectfully submit that the prior art does not teach the skewing of the throat or sonic plane of a nozzle as taught and claimed by the present invention. Additionally, the nozzle's thrust efficiency is greatly increased in the present invention. One might encounter an efficiency of 0.9 when using shock vector control, while one would encounter 0.95 with the small area expansion ratio nozzle claimed by the present invention.

The Applicants respectfully submit that Warren teaches away from the subject matter of the present invention in that Warren teaches a thrust-vectoring system for a reaction jet nozzle wherein a pulse flow is injected at the throat in order to vector the primary fluid. The pulsed fluid is of short duration and thus continuous control fluid streams are not required to maintain a proper deflection of the propelling

jet. (Warren: column 9, lines 63-67). Additionally, the Applicants respectfully submit that Warren vectors the primary flow through the Coanda effect. Warren can be distinguished from the present invention as Warren teaches that the primary flow may be vectored by the Coanda effect (a wall attachment effect). Warren describes that a single fluid pulse or jet issuing from one of the control nozzles will cause the propelling jet (primary flow) to lock on and remain locked on to the nozzle wall in the absence of another fluid pulse from another control nozzle. (Warren: column 9, lines 59-63.) Coanda observed that a stream of fluid exiting a nozzle tends to follow a nearby curved or flat surface as long as the curvature of the surface with respect to the fluid flow is not too sharp.

The Applicants submit that the present invention as recited in independent Claims 31, 44, 51, and 63 do not utilize the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, location, and orientation of the nozzle throat. This allows a user to not merely manipulate the direction of the primary flow through in a discrete fashion as taught in the prior art with the use of the Coanda effect. Rather, one can continuously vector the primary flow and area, location, and orientation of the nozzle throat.

The Applicants respectfully submit that the Coanda effect merely allows the creation of a binary device where the thrust may be vectored either in a first or second direction. The present invention in comparison claims a smooth and continuous control system for vectoring the exhaust thrust by

manipulating the size, location, and orientation of the sonic plane within the nozzle throat.

Applicants respectfully submit that in an alternate embodiment, Warren still only teaches the Coanda effect to provide a tri-stable flow patter. Warren states that in this embodiment, that control fluid, supplied through one wall to the separated boundary layer, causes deflection of the propelling jet away from the control fluid input. The propelling jet thereupon clings to the opposite wall until the control signal is discontinued, at which time it returns to a center flow position (Warren: column 9, line 72; column 10, line 4).

The Applicants respectfully submit that the present invention does not provide a pulsed control signal to serve as a binary switch for vectoring the primary flow of a nozzle, rather the present invention claims a pulsed cross flow that provides a smooth, continuous control signal with which to vector the primary flow of the nozzle by controlling the size, location, and orientation of the sonic plane (or throat) of the nozzle in the present invention. This is taught in the present invention as the pulsed fluidic cross flow that has a predetermined frequency, amplitude or wave injector that is controlled by a controller associated with the injector (U.S. patent Application 08/906,731; page 16, lines 1-25).

The present invention is distinguishable from the prior art of Warren, which utilizes the Coanda effect. A fluidic amplifier device such as those taught in Warren is not robust against errors in the control function as the Coanda effect is unstable as downstream disturbances may propagate upstream in the exhaust flow to redirect the primary flow from one wall of the divergent portion of the nozzle to another. This type of thrust vector control is inadequate for uses such as aircraft control, as claimed by the present invention.

Therefore, the Applicants respectfully submit that one would not apply the teachings of McCullough, Kranz et al., or Warren to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

Claims 31-50 are rejected under 35 USC 103(a) as being unpatentable over **either** McCullough (3,698,642) in view of either Ernst (3,294,323) or the AIAA paper of Miller et al. (AIAA 95-2603) and further in view of either Kranz et al. (4,351,479) **or** Warren (3,204,405) **or** AIAA paper of Miller et al. (AIAA 95-2603) of the IDS in view of McCullough (3,698,642) and either Kranz et al. (4,351,479) or Warren (3,204,405), as applied above, and further in view of either Terrier (5,665,415) or Justice (6,000,635). The above prior art teach various aspects of applicant's claimed invention but do not specifically teach a 3-D fixed nozzle. Terrier teaches (fig. 8) that ultra high aspect ratio biconvex aperture nozzles are old and well known in the fixed nozzle art. Justice teaches that it is old and well known in the fixed nozzle art employ an ultra high aspect ratio trapezoid aperture nozzle 33B (col. 2, circa line 63). It would have been obvious to one of ordinary skill in the art employ a 3-D nozzle, including either an ultra high aspect ratio biconvex or trapezoid aperture nozzle, as well as known types of fixed nozzles utilized in the art.

Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous,

nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims in Claim 75 that the asymmetric cross flow from the injectors skews sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

The Applicants respectfully teach that Ernest teaches away from the subject matter of the present invention in that Ernest teaches thrust vectoring through the use of liquid vaporizations (Ernest; col. 2, lines 35-40). The present invention does not inject a liquid which then undergoes a phase change (vaporization) into the primary fluid flow. Additionally, the Applicants respectfully submit that Ernest vectors the primary flow through the Coanda effect. Ernest can be distinguished from the present invention as Ernest teaches that the primary flow may be vectored by a wall attachment effect. Ernest describes that a single liquid injection will cause the primary flow to lock on and remain locked on to the nozzle wall in the absence of another liquid injection (Ernest; col. 2, lines 5-13). Additionally, Ernest does not teach that the effective sonic plane and throat of the nozzle are skewed by the injection of liquid into the primary flow.

The Applicants submit that the present invention as recited in the claims does not use the Coanda effect. Rather,

the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, effective location, and effective orientation of the nozzle throat or sonic plane, no matter the physical configuration of the nozzle or duct containing the primary flow.

The Examiner states that Kranz teaches a nozzle having a plurality of injectors based about a nozzle to provide an unsteady fluidic flow. The pulsed cross flow is injected to control the effective flow area, throttle and vector the primary fluidic flow (Kranz: column 5, lines 9 and following). The Applicants respectfully submit that Kranz et al. also teaches the use of the Coanda effect with fluidic jet deflection by control pulses which shift the primary flow from one wall of the nozzle to another wall of the nozzle (Kranz: column 1, lines 24-30). Furthermore, Kranz et al. states that a control pulse is only necessary for the duration of the switching process. As soon as the thrust jet (primary flow) is deflected into one of the pockets shown in 16-20 (shown in Kranz Figure 1), the primary flow remains automatically and without any further control pulse under the action of the Coanda effect (Kranz: column 1, lines 9-28).

One skilled in the art would not apply the teachings of Kranz et al. to the present invention in that Kranz teaches according to the historical approach of shock vector control. This is applicable where a nozzle has an expansion area ratio typically between 3 to 10. Such a nozzle is widened beyond the expansion ratio corresponding to the ambient pressure (Kranz: column 1, lines 17-19). Throat skewing as claimed by the present invention cannot be applied to an over-expanded nozzle. Furthermore, the Applicants respectfully submit that shock vector control also cannot be applied to the small area

expansion ratio nozzle as taught and claimed by the present invention. The present invention injects the secondary flow into the subsonic portion of the flow field preventing the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-17). The Applicants respectfully submit that the prior art does not teach the skewing of the throat or sonic plane of a nozzle as taught and claimed by the present invention. Additionally, the nozzle's thrust efficiency is greatly increased in the present invention. One might encounter an efficiency of 0.9 when using shock vector control, while one would encounter 0.95 with the small area expansion ratio nozzle claimed by the present invention.

The Applicants respectfully submit that Warren teaches away from the subject matter of the present invention in that Warren teaches a thrust-vectoring system for a reaction jet nozzle wherein a pulse flow is injected at the throat in order to vector the primary fluid. The pulsed fluid is of short duration and thus continuous control fluid streams are not required to maintain a proper deflection of the propelling jet. (Warren: column 9, lines 63-67). Additionally, the Applicants respectfully submit that Warren vectors the primary flow through the Coanda effect. Warren can be distinguished from the present invention as Warren teaches that the primary flow may be vectored by the Coanda effect (a wall attachment effect). Warren describes that a single fluid pulse or jet issuing from one of the control nozzles will cause the propelling jet (primary flow) to lock on and remain locked on to the nozzle wall in the absence of another fluid pulse from another control nozzle. (Warren: column 9, lines 59-63.) Coanda observed that a stream of fluid exiting a nozzle tends to follow a nearby curved or flat surface as long as the

curvature of the surface with respect to the fluid flow is not too sharp.

The Applicants submit that the present invention as recited in Claims 31, 44, 51, and 63 do not utilize the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, location, and orientation of the nozzle throat. This allows a user to not merely manipulate the direction of the primary flow through in a discrete fashion as taught in the prior art with the use of the Coanda effect. Rather, one can continuously vector the primary flow and area, location, and orientation of the nozzle throat.

The Applicants respectfully submit that the Coanda effect merely allows the creation of a binary device where the thrust may be vectored either in a first or second direction. The present invention in comparison claims a smooth and continuous control system for vectoring the exhaust thrust by manipulating the size, location, and orientation of the sonic plane within the nozzle throat.

Applicants respectfully submit that in an alternate embodiment, Warren still only teaches the Coanda effect to provide a tri-stable flow patter. Warren states that in this embodiment, that control fluid, supplied through one wall to the separated boundary layer, causes deflection of the propelling jet away from the control fluid input. The propelling jet thereupon clings to the opposite wall until the control signal is discontinued, at which time it returns to a center flow position (Warren: column 9, line 72; column 10, line 4).

The Applicants respectfully submit that the present invention does not provide a pulsed control signal to serve as a binary switch for vectoring the primary flow of a nozzle, rather the present invention claims a pulsed cross flow that provides a smooth, continuous control signal with which to vector the primary flow of the nozzle by controlling the size, location, and orientation of the sonic plane (or throat) of the nozzle in the present invention. This is taught in the present invention as the pulsed fluidic cross flow that has a predetermined frequency, amplitude or wave injector that is controlled by a controller associated with the injector (U.S. patent Application 08/906,731; page 16, lines 1-25).

The present invention is distinguishable from the prior art of Warren, which utilizes the Coanda effect. A fluidic amplifier device such as those taught in Warren is not robust against errors in the control function as the Coanda effect is unstable as downstream disturbances may propagate upstream in the exhaust flow to redirect the primary flow from one wall of the divergent portion of the nozzle to another. This type of thrust vector control is inadequate for uses such as aircraft control, as claimed by the present invention.

Therefore, the Applicants respectfully submit that one would not apply the teachings of McCullough, Kranz et al., or Warren to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

Withdrawal of Final Rejection

The Applicants respectfully submit that the Rejection within the Office Action dated May 31, 2002 is premature. The Applicants submit that the claims as originally submitted and now amended provide a system and method for vectoring a primary flow within a nozzle by skewing the effective throat or sonic plane of the nozzle. This is not taught in the cited prior art.

The claimed invention as taught and claimed is improperly rejected by the cited prior art.

Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims in Claim 75 that the asymmetric cross flow from the injectors skews sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

The Applicants respectfully teach that Ernest teaches away from the subject matter of the present invention in that Ernest teaches thrust vectoring through the use of liquid vaporizations (Ernest; col. 2, lines 35-40). The present

invention does not inject a liquid which then undergoes a phase change (vaporization) into the primary fluid flow. Additionally, the Applicants respectfully submit that Ernest vectors the primary flow through the Coanda effect. Ernest can be distinguished from the present invention as Ernest teaches that the primary flow may be vectored by a wall attachment effect. Ernest describes that a single liquid injection will cause the primary flow to lock on and remain locked on to the nozzle wall in the absence of another liquid injection (Ernest; col. 2, lines 5-13). Additionally, Ernest does not teach that the effective sonic plane and throat of the nozzle are skewed by the injection of liquid into the primary flow.

The Applicants submit that the present invention as recited in the claims does not use the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, effective location, and effective orientation of the nozzle throat or sonic plane, no matter the physical configuration of the nozzle or duct containing the primary flow.

The Examiner states that Kranz teaches a nozzle having a plurality of injectors based about a nozzle to provide an unsteady fluidic flow. The pulsed cross flow is injected to control the effective flow area, throttle and vector the primary fluidic flow (Kranz: column 5, lines 9 and following). The Applicants respectfully submit that Kranz et al. also teaches the use of the Coanda effect with fluidic jet deflection by control pulses which shift the primary flow from one wall of the nozzle to another wall of the nozzle (Kranz: column 1, lines 24-30). Furthermore, Kranz et al. states that a control pulse is only necessary for the duration of the

switching process. As soon as the thrust jet (primary flow) is deflected into one of the pockets shown in 16-20 (shown in Kranz Figure 1), the primary flow remains automatically and without any further control pulse under the action of the Coanda effect (Kranz: column 1, lines 9-28).

One skilled in the art would not apply the teachings of Kranz et al. to the present invention in that Kranz teaches according to the historical approach of shock vector control. This is applicable where a nozzle has an expansion area ratio typically between 3 to 10. Such a nozzle is widened beyond the expansion ratio corresponding to the ambient pressure (Kranz: column 1, lines 17-19). Throat skewing as claimed by the present invention cannot be applied to an over-expanded nozzle. Furthermore, the Applicants respectfully submit that shock vector control also cannot be applied to the small area expansion ratio nozzle as taught and claimed by the present invention. The present invention injects the secondary flow into the subsonic portion of the flow field preventing the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-17). The Applicants respectfully submit that the prior art does not teach the skewing of the throat or sonic plane of a nozzle as taught and claimed by the present invention. Additionally, the nozzle's thrust efficiency is greatly increased in the present invention. One might encounter an efficiency of 0.9 when using shock vector control, while one would encounter 0.95 with the small area expansion ratio nozzle claimed by the present invention.

The Applicants respectfully submit that Warren teaches away from the subject matter of the present invention in that Warren teaches a thrust-vectoring system for a reaction jet nozzle wherein a pulse flow is injected at the throat in order

to vector the primary fluid. The pulsed fluid is of short duration and thus continuous control fluid streams are not required to maintain a proper deflection of the propelling jet. (Warren: column 9, lines 63-67). Additionally, the Applicants respectfully submit that Warren vectors the primary flow through the Coanda effect. Warren can be distinguished from the present invention as Warren teaches that the primary flow may be vectored by the Coanda effect (a wall attachment effect). Warren describes that a single fluid pulse or jet issuing from one of the control nozzles will cause the propelling jet (primary flow) to lock on and remain locked on to the nozzle wall in the absence of another fluid pulse from another control nozzle. (Warren: column 9, lines 59-63.) Coanda observed that a stream of fluid exiting a nozzle tends to follow a nearby curved or flat surface as long as the curvature of the surface with respect to the fluid flow is not too sharp.

The Applicants submit that the present invention as recited in Claims 31, 44, 51, and 63 do not utilize the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, location, and orientation of the nozzle throat. This allows a user to not merely manipulate the direction of the primary flow through in a discrete fashion as taught in the prior art with the use of the Coanda effect. Rather, one can continuously vector the primary flow and area, location, and orientation of the nozzle throat.

The Applicants respectfully submit that the Coanda effect merely allows the creation of a binary device where the thrust may be vectored either in a first or second direction. The present invention in comparison claims a smooth and continuous

control system for vectoring the exhaust thrust by manipulating the size, location, and orientation of the sonic plane within the nozzle throat.

Applicants respectfully submit that in an alternate embodiment, Warren still only teaches the Coanda effect to provide a tri-stable flow patter. Warren states that in this embodiment, that control fluid, supplied through one wall to the separated boundary layer, causes deflection of the propelling jet away from the control fluid input. The propelling jet thereupon clings to the opposite wall until the control signal is discontinued, at which time it returns to a center flow position (Warren: column 9, line 72; column 10, line 4).

The Applicants respectfully submit that the present invention does not provide a pulsed control signal to serve as a binary switch for vectoring the primary flow of a nozzle, rather the present invention claims a pulsed cross flow that provides a smooth, continuous control signal with which to vector the primary flow of the nozzle by controlling the size, location, and orientation of the sonic plane (or throat) of the nozzle in the present invention. This is taught in the present invention as the pulsed fluidic cross flow that has a predetermined frequency, amplitude or wave injector that is controlled by a controller associated with the injector (U.S. patent Application 08/906,731; page 16, lines 1-25).

The present invention is distinguishable from the prior art of Warren, which utilizes the Coanda effect. A fluidic amplifier device such as those taught in Warren is not robust against errors in the control function as the Coanda effect is unstable as downstream disturbances may propagate upstream in the exhaust flow to redirect the primary flow from one wall of the divergent portion of the nozzle to another. This type of

thrust vector control is inadequate for uses such as aircraft control, as claimed by the present invention.

Therefore, the Applicants respectfully submit that one would not apply the teachings of McCullough, Kranz et al., or Warren to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

CONCLUSION

Applicants have now made an earnest attempt to place this case in condition for allowance. For the foregoing reasons, and for other reasons clearly apparent, Applicants respectfully request full allowance of Claims 31-33, 35-42, 44, 46-49, 51-57, 59-63, 65-68, and 75-77.

It is believed no fee is due with this submission, however, should a fee be determined to be due, the Commissioner is hereby authorized to charge any fees or credit any overpayments to Hughes & Luce LLP Deposit Account No. 50-1343.

Respectfully submitted,

HUGHES & LUCE LLP

Date: August 8, 2002

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MARKED-UP COPY OF CLAIMS ACCORDING TO 37 CFR § 1.121(c)(1)(i)

31. (Amended) [A nozzle for vectoring a primary flow of a fluid flowing through an enclosed volume, the nozzle being a 3-D nozzle and having an inside surface, the nozzle comprising:

a plurality of injectors with port openings arranged along the inside surface of the 3-D nozzle, each of the plurality of injectors adapted to expel an injection fluid in a direction within the enclosed volume, the direction inclined to oppose the primary flow of the fluid and approximately parallel to an intended vectoring plane.]A system for vectoring a primary flow by varying an effective throat or sonic plane within a ducted primary flow, comprising:

an opening for accepting the primary flow;

at least one primary injector located wherein said at least one injector is inclined to oppose the primary flow upstream of said effective throat or sonic plane;

at least one supplemental injector wherein said at least one supplemental injector is located downstream of the at least one primary injector, wherein said at least one supplemental injector is inclined to oppose the primary flow, and wherein the at least one primary and supplemental injectors provide a flow field opposed to a subsonic portion of the primary flow in order to vector the primary flow; and

at least one controller operable to direct said at least one primary and supplemental injector to provide a flow operable to vary the effective throat or sonic plane.

32. (Amended) The [nozzle of]system for vectoring a primary flow of Claim 31, [the nozzle]further comprising:

a physical throat, [the]within a duct, wherein the physical throat [comprising]comprises a region [within the

nozzle] of lowest cross-sectional area, **[the throat being] [situation]** in **[a path of]** the primary flow **[of the fluid]**.

33. (Amended) The **[nozzle]** **system for vectoring a primary flow** of Claim 32 wherein **[the]** a plurality of **primary** injectors is located proximate to **[the]** **said physical** throat.

34. **Cancelled.**

35. (Amended) The **[nozzle]** **system for vectoring a primary flow** of Claim **[34]** 31 wherein **[the plurality of]** injectors **[and the second plurality of injectors expel the injection]** inject fluid asymmetrically, to **[resulting in a change in a thrust]** **redirect** **[vector associated with]** the primary flow **[of the fluid, the change in the thrust vector lying within]** **along** **[the]** **an** intended vectoring plane.

36. (Amended) The [nozzle] **system for vectoring a primary flow** of Claim 35 wherein **[the]** a plurality of **primary and secondary** injectors **[and the second plurality of injectors]** inject fluidic **[expel the injection fluid in]** pulses.

37. (Amended) The [nozzle] **system for vectoring a primary flow** of Claim 33, **[the nozzle further comprising:]** **wherein a** **[a second]** plurality of **secondary** injectors **[located proximate to the throat, the second plurality of injectors having port openings]** **are** arranged **[along the inside surface opposite of the plurality of injectors, each of the second plurality of injectors adapted to expel the injection]** **to inject** fluid **[in a second direction within the enclosed volume, the second direction inclined]** to oppose the primary flow **[of the fluid and approximately]** **and in** parallel to the intended vectoring plane.

38. (Amended) The [nozzle] **system for vectoring a primary flow** of Claim 37 wherein the plurality of **primary** injectors

and the **[second]** plurality of **secondary** injectors **[expel the injection]** **inject** fluid symmetrically, resulting in a change in a discharge coefficient in the nozzle.

39. **Cancelled.**

40. (Amended) The **[nozzle]** **system for vectoring a primary flow** of Claim 31 wherein **[the injection]** **injected** fluid **[is a]** **comprises** compressed gas.

41. (Amended) The **[nozzle]** **system for vectoring a primary flow** of Claim 31 wherein **[the injection]** **injected** fluid **comprises** fuel.

42. (Amended) The **[nozzle]** **system for vectoring a primary flow** of Claim 31, **[the nozzle]** further comprising:

at least one controller, **[the at least one controller]** operable to direct **[at least one of the plurality of injectors to expel the injection fluid]** **said at least one primary injector and/or said at least one supplemental injector**.

43. Cancelled.

44. (Amended) A method for vectoring a primary flow of fluid in a 3-D nozzle, **[the 3-D nozzle having a throat, the throat comprising a region within the 3-D nozzle of lowest cross-sectional area, the throat being situated in a path of the primary flow of fluid, the method]** comprising **the steps of**:

[expelling] **injecting fluid** from a plurality of **primary** injectors **[an injection fluid in a direction inclined to oppose the]** **opposed to a** primary flow of the fluid and approximately parallel to an intended vectoring plane, the plurality of injectors located proximate to **[the]** **a** throat **[.]** ;

injecting fluid from a plurality of supplemental injectors opposed to the primary flow wherein said second plurality of supplemental injectors are located downstream of the throat, and wherein the fluid injected by said primary and/or supplemental injectors varies or skews an effective throat or sonic plane of said 3-D nozzle.

45. Cancelled.

46. (Amended) The method of Claim 44, **[the method]** further comprising:

expelling from a second plurality of injectors the injection fluid in a direction inclined to oppose the primary flow of the fluid and approximately parallel to an intended vectoring plane, **[the second]** **wherein said supplemental** plurality of injectors **are** located **[approximate]** **proximate** to the throat.

47. (Amended) The method of Claim 44 wherein **[the step of expelling comprises expelling in pulses.]** **fluid is injected by said primary and/or supplemental injectors in fluidic pulses.**

48. (Amended) The method of Claim 44 wherein the **[injection]** **injected** fluid **[is]** **comprises** a compressed gas.

49. (Amended) The method of Claim 44 wherein the **[injection]** **injected** fluid **[is a]** **comprises** fuel.

50. Cancelled.

51. (Amended) A **[nozzle for]** **system for** vectoring a primary flow **[of fluid, the primary flow of fluid flowing through an enclosed volume, the]** **comprising:**

a nozzle having an **[inside]** **inner** surface and a throat, **wherein** the throat **[comprising]** **comprises** a region

within the nozzle of lowest cross-sectional area, the throat being situated in a path of the primary flow of fluid**[,]**; **[the nozzle comprising:]**

a plurality of primary injectors **[with port openings]** arranged along the **[inside]** inner surface of the nozzle, the plurality of injectors arranged **[such that the plurality of injectors are not aligned parallel to the path of the primary flow of fluid, each of the plurality of injectors adapted to expel an injection fluid in a direction within the enclosed volume, the direction inclined]** to oppose the primary flow of fluid **[and]** in a first **[approximately parallel to an]** intended vectoring plane**[.]**, **and wherein said primary injectors skew an effective throat or sonic plane within said nozzle.**

52. (Amended) The **[nozzle]** **system for vectoring a primary flow** of Claim 51 wherein the plurality of injectors is located proximate to the throat.

53. (Amended) The **[nozzle]** **system for vectoring a primary flow** of Claim 52, **[the nozzle]** further comprising:

a **[second]** plurality of **supplemental** injectors located downstream of the throat and arranged along the **[inside]** **inner** surface of the nozzle, **[the second plurality of injectors arranged such that the second plurality of injectors are not aligned parallel to the path of the primary flow of fluid, each of the second plurality of injectors adapted to expel the injection fluid in a second direction within the enclosed volume, the second direction inclined]** to oppose the primary flow **[of the fluid and approximately parallel to the]** **in a second** intended vectoring plane.

54. (Amended) The **[nozzle]** **system for vectoring a primary flow** of Claim 53 wherein the plurality of **primary and**

supplemental injectors **[and the second plurality of injectors expel the injection]** **inject** fluid asymmetrically, resulting in a change in a thrust vector associated with the primary flow of the fluid, the change in the thrust vector lying within the **first and/or second** intended vectoring plane.

55. (Amended) The **[nozzle]** **system for vectoring a primary flow** of Claim 54 wherein the plurality of **primary and supplemental** injectors **[and the second plurality of injectors expel the injection fluid in pulses]** **inject fluidic pulses**.

56. (Amended) The **[nozzle]** **system for vectoring a primary flow** of Claim [52] 53, **[the nozzle further comprising:]** **wherein said supplemental injectors are:**

[a second plurality of injectors] located proximate to the throat **[, the second plurality of injectors having port openings arranged along the inside surface opposite of the plurality of injectors, the second plurality of injectors arranged such that the second plurality of injectors are not aligned parallel to the path of the primary flow of fluid, each of the second plurality of injectors adapted to expel the injection fluid in a second direction within the enclosed volume, the second direction inclined to oppose the primary flow of the fluid and approximately parallel to the intended vectoring plane]**.

57. (Amended) The **[nozzle]** **system for vectoring a primary flow** of Claim 56 wherein the plurality of **primary and/or supplemental** injectors **[and the second plurality of injectors expel the injection]** **inject** fluid symmetrically, resulting in a change in a discharge coefficient **[in]** **for** the nozzle.

58. Cancelled.

59. (Amended) The [nozzle] **system for vectoring a primary flow** of Claim 51 wherein the [injection] **injected** fluid [is a] **comprises** compressed gas.

60. (Amended) The [nozzle] **system for vectoring a primary flow** of Claim 51 wherein the [injection] **injected** fluid [is] **comprises** fuel.

61. (Amended) The [nozzle] **system for vectoring a primary flow** of Claim [54] **53**, [the nozzle] further comprising:

at least one controller, [the at least one controller] operable to direct [at least one of the plurality of] **said primary and/or supplemental** injectors[to expel the injection fluid].

62. (Amended) The [nozzle] **system for vectoring a primary flow** of Claim [51] **61**, [the nozzle further comprising:]

wherein said at least one controller, [the at least one controller operable to direct] **directs** [at least one of the plurality of] **said primary and/or supplemental** injectors to [expel of the injection] **inject** [fluid in pulses] **fluidic pulses**.

63. (Amended) A method for vectoring a primary flow [of fluid in a nozzle, the nozzle having a throat, the throat comprising a region within the nozzle of lowest cross-sectional area, the throat being situated in a path of the primary flow of fluid, the method] **within a nozzle** comprising **the steps of**:

[expelling] **injecting** from a plurality of **primary** injectors [an injection] **a** fluid [in a direction inclined to oppose] **opposed to** the primary flow [of the fluid and approximately parallel to an intended vectoring plane, the] **wherein said** plurality of **primary** injectors **are** located

proximate to [the]a throat **[and arranged such that the plurality of injectors are not aligned parallel to the path of the primary flow of fluid]of the nozzle**[.]**;**

injecting from a plurality of supplemental injectors fluid to oppose the primary flow, the plurality of supplemental injectors located downstream of the throat, wherein said injected fluid skews or varies an effective throat or sonic plane within the nozzle.

64. Cancelled.

65. (Amended) The method of Claim 63, **[the method further comprising:**

expelling from a second plurality of injectors an injection fluid in a direction inclined to oppose the primary flow of the fluid and approximately parallel to an intended vectoring plane, the second plurality of injectors located approximate to the throat and arranged such that the second plurality of injectors are not aligned parallel to the path of the primary flow of fluid]wherein said supplemental injectors are located proximate to the throat.

66. (Amended) The method of Claim 63 wherein **[the step of expelling comprises expelling in pulses]fluid is injected as fluidic pulses**.

67. (Amended) The method of Claim 63 wherein the **[injection]injected** fluid **[is a]comprises** compressed gas.

68. (Amended) The method of Claim 63 wherein the **[injection]injected** fluid **[is a]comprises** fuel.

69. Cancelled.

70. Cancelled.

71. Cancelled.

72. Cancelled.

73. Cancelled.

74. Cancelled.

75. (New) The system of Claim 31, wherein a location, size, and/or orientation of said effective throat are varied.

76. (New) The system of Claim 31, wherein a fluidic pulse from said at least one supplemental injector is operable to skew a boundary of the sonic plane of the primary flow towards said at least one supplemental injector.

77. (New) The system of Claim 31, wherein the primary flow has a temperature and wherein said pulsed secondary flow throttles the primary flow by decreasing the effective cross sectional area of the effective throat to control said temperature of the primary flow.